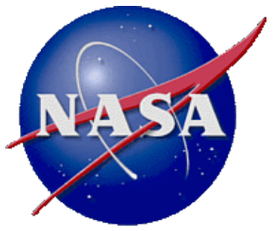

The Flux of Large Meteoroids Observed with Lunar Impact Monitoring

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8 Years of Observations

- The MSFC lunar impact monitoring program began in 2006 in support of environment definition for the Constellation (return to Moon) program.
- Work continued by the Meteoroid Environment Office after Constellation cancellation.
- Over 300 impacts have been recorded
- A paper published in Icarus reported on the first 5 years of observations and 126 calibrated flashes

Icarus: http://www.sciencedirect.com/science/article/pii/S0019103514002243

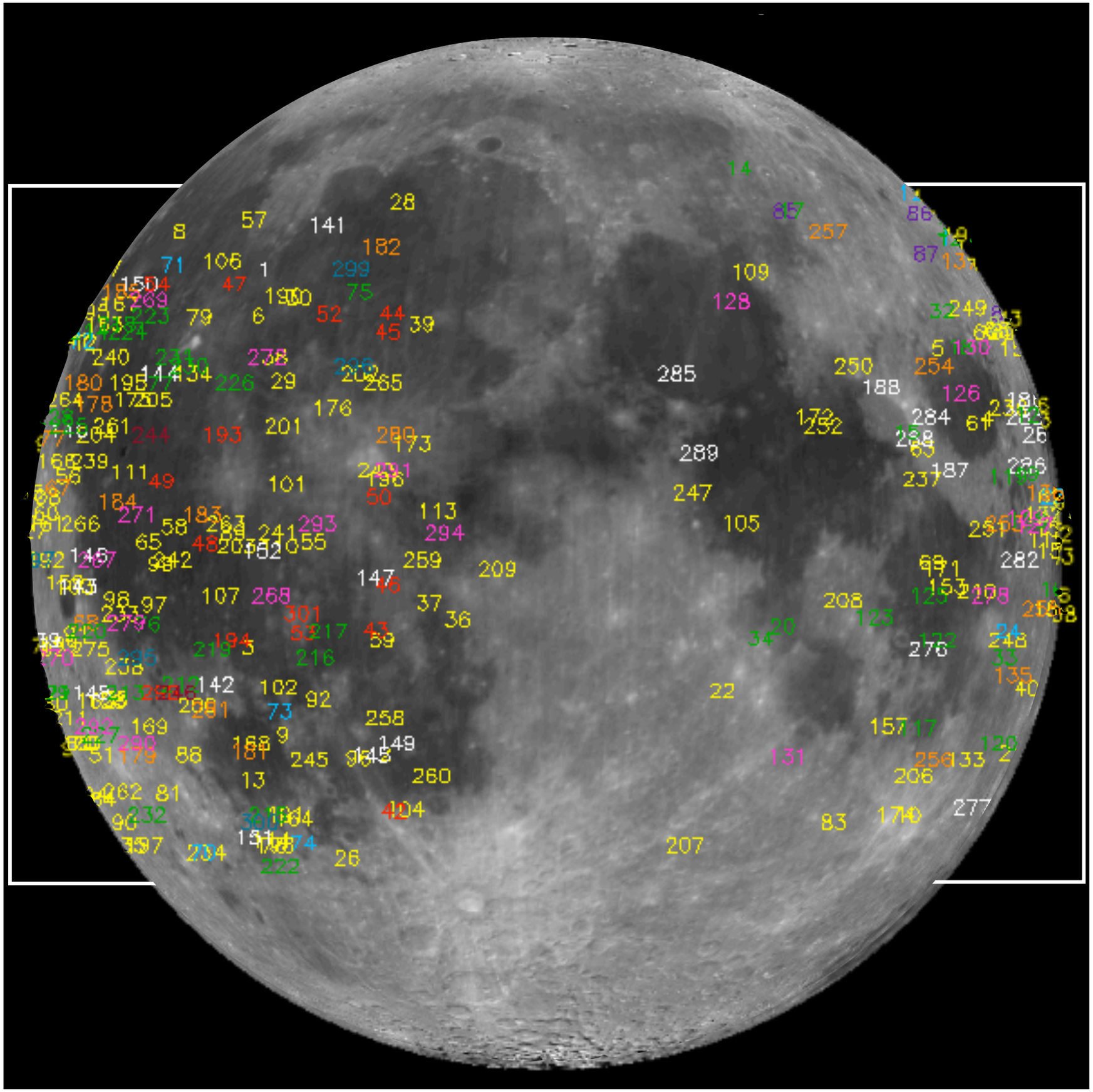
ArXiv: http://arxiv.org/abs/1404.6458

Automated Lunar and Meteor Observatory

MSFC, Huntsville, Alabama

- Three 0.35m telescopes (Celestron/Meade)
- Detector - Watec 902H2 Ultimate (γ = 0.45, manual gain, shutter off)

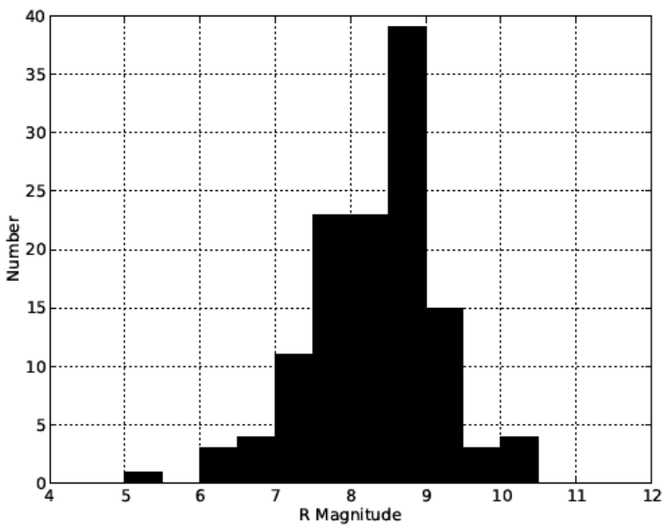
Mayhill, New Mexico



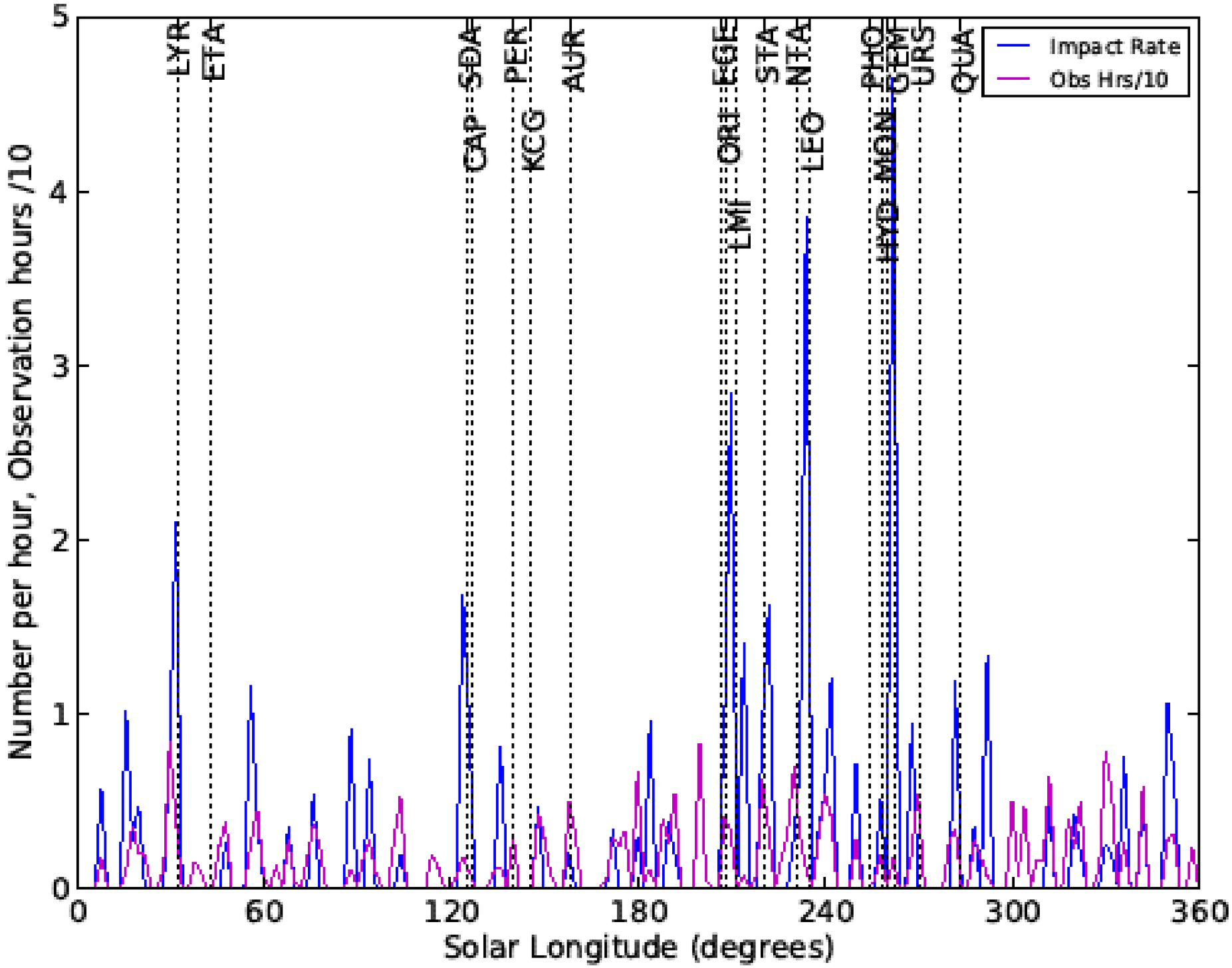
300+ impacts since 2005

Subset of 126 flashes:
141 hrs evening - 81 flashes
126 hrs morning - 45 flashes

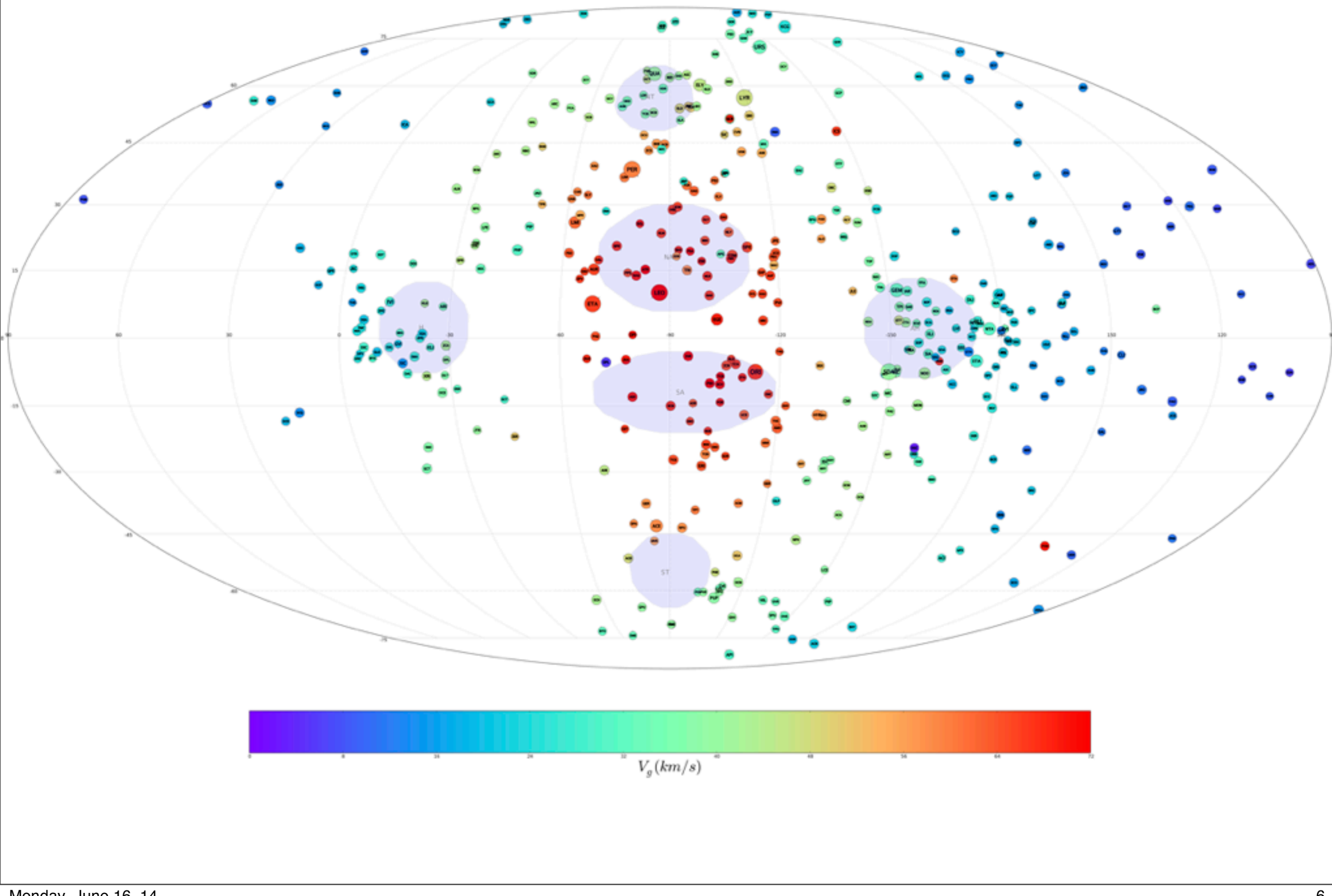
Average: 2.1 hrs/flash
evening/morning = 1.61:1

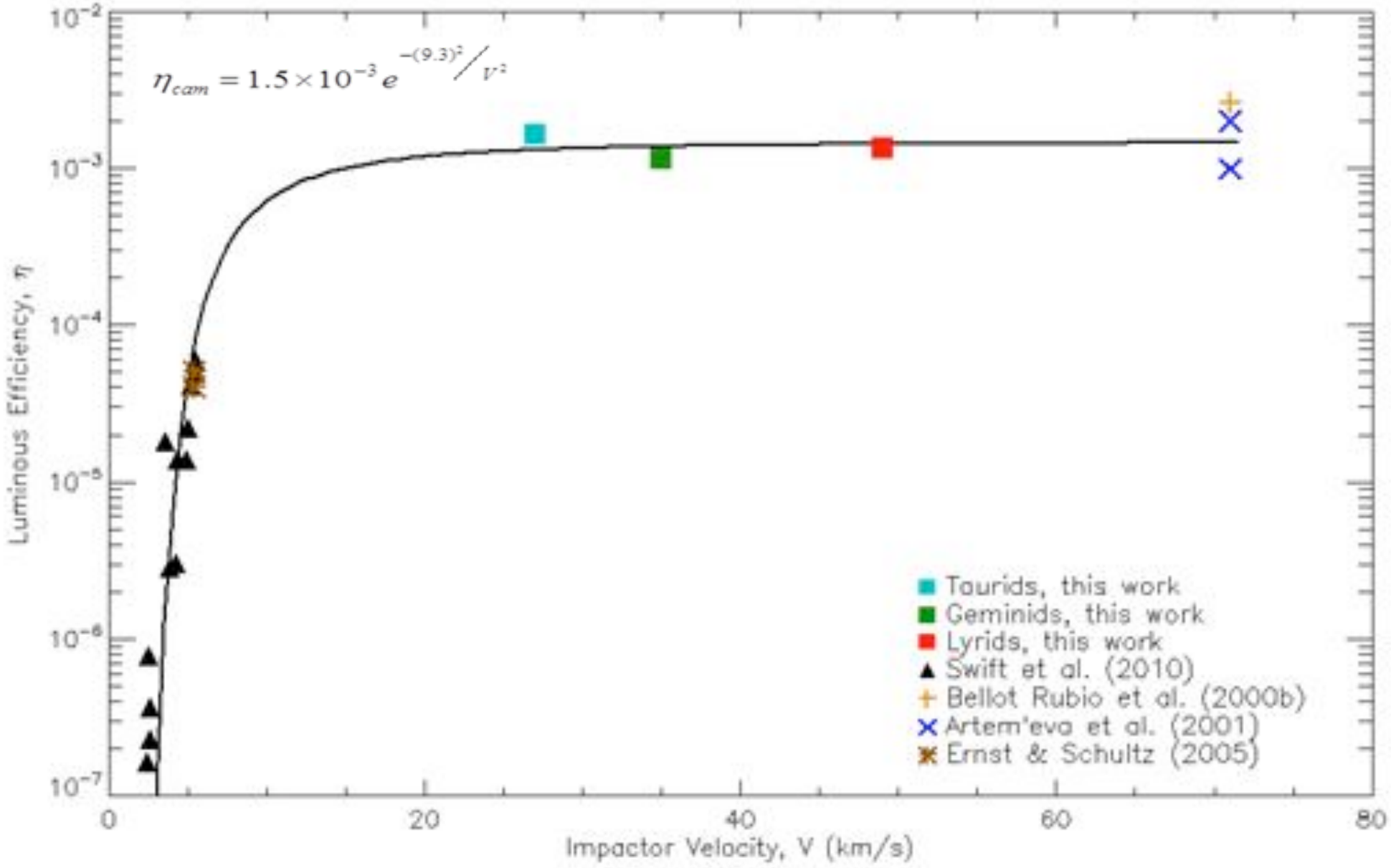


Photometric error ~0.2 mag

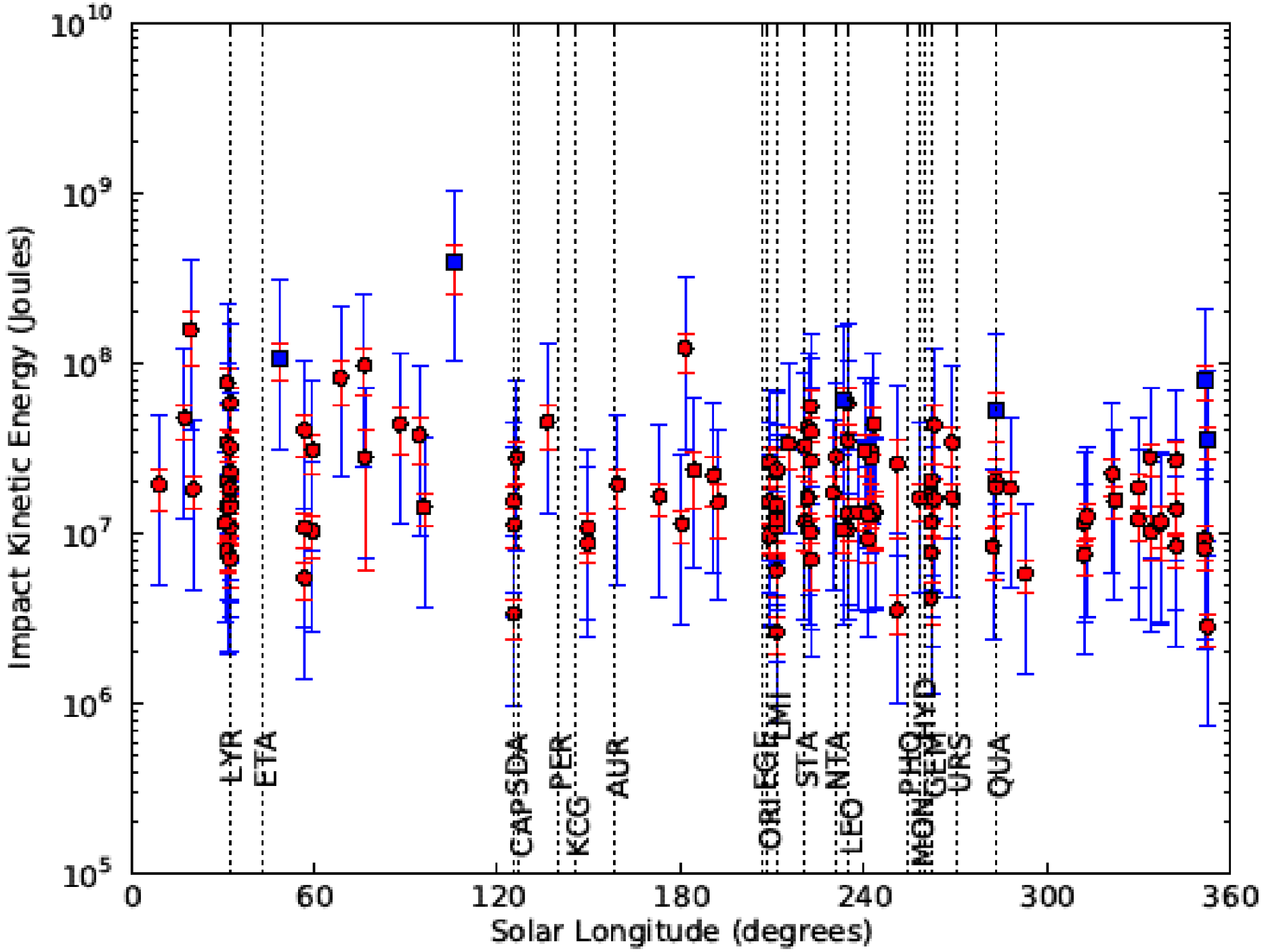

LYR
ETA
SDA
CAP
PER
KCG
AUR
EGE
ORI
LMI
STA
NTA
LEO
PHO
HYD
GEM
URS
QUA
Impact Rate
Obs Hrs/10
Number per hour, Observation hours /10
0
1
2
3
4
5
0
60
120
180
240
300
360
Solar Longitude (degrees)

Meteor Shower and Sporadic Source Radiants





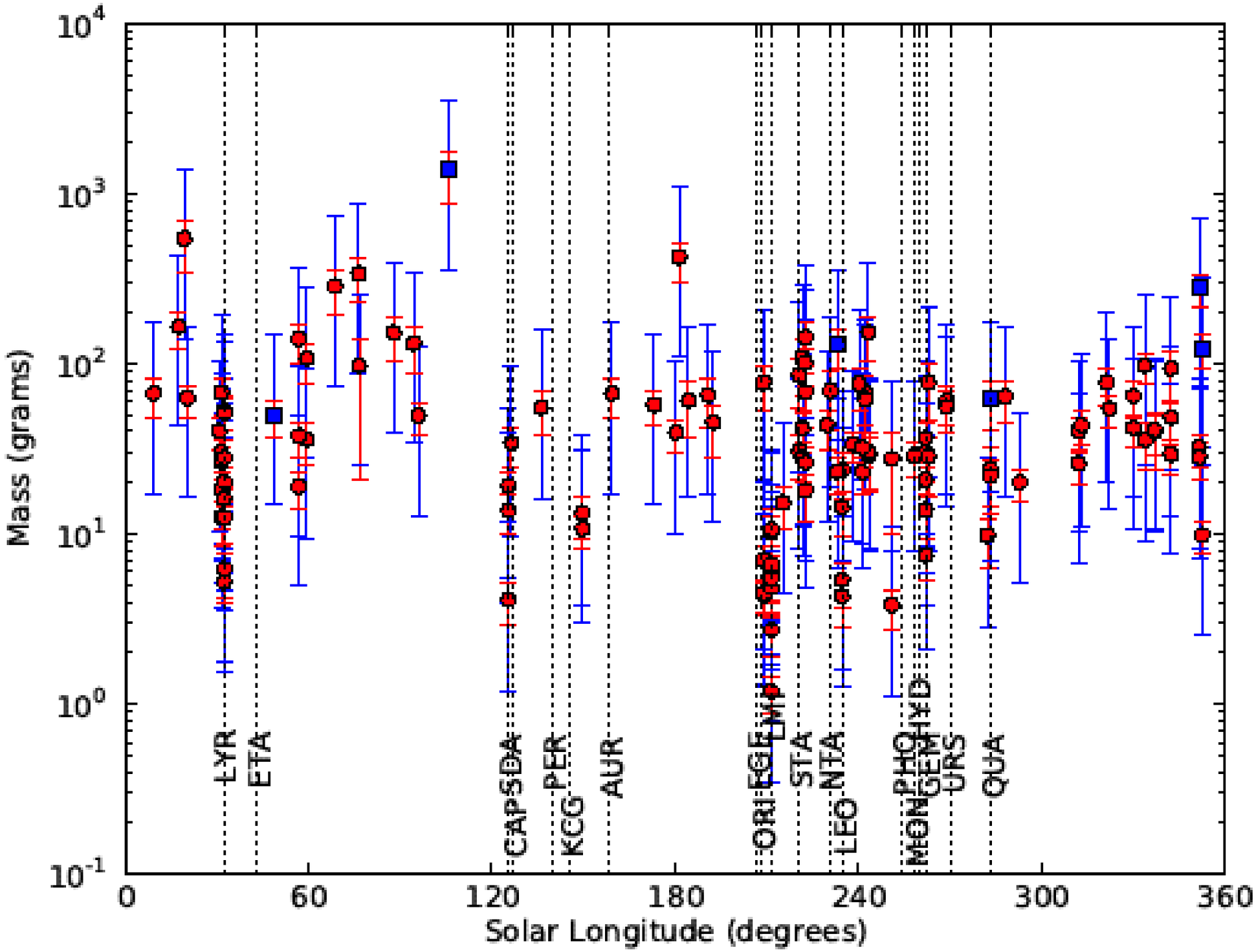
Moser, D.E. et al., "Luminous Efficiency of Hypervelocity Meteoroid Impacts on the Moon Derived from the 2006 Geminids, 2007 Lyrids, and 2008 Taurids", Meteoroids 2010 Proceedings (NASA CP-2011-216469)



Red error bars - photometric uncertainty; Blue error bars - luminous efficiency uncertainty
Squares indicate saturation

The flux to a limiting energy of 2.5×10^{-6} kT TNT or 1.05×10^{7} J is 1.03×10^{-7} km^{-2} hr^{-1}

National Aeronautics and Space Administration

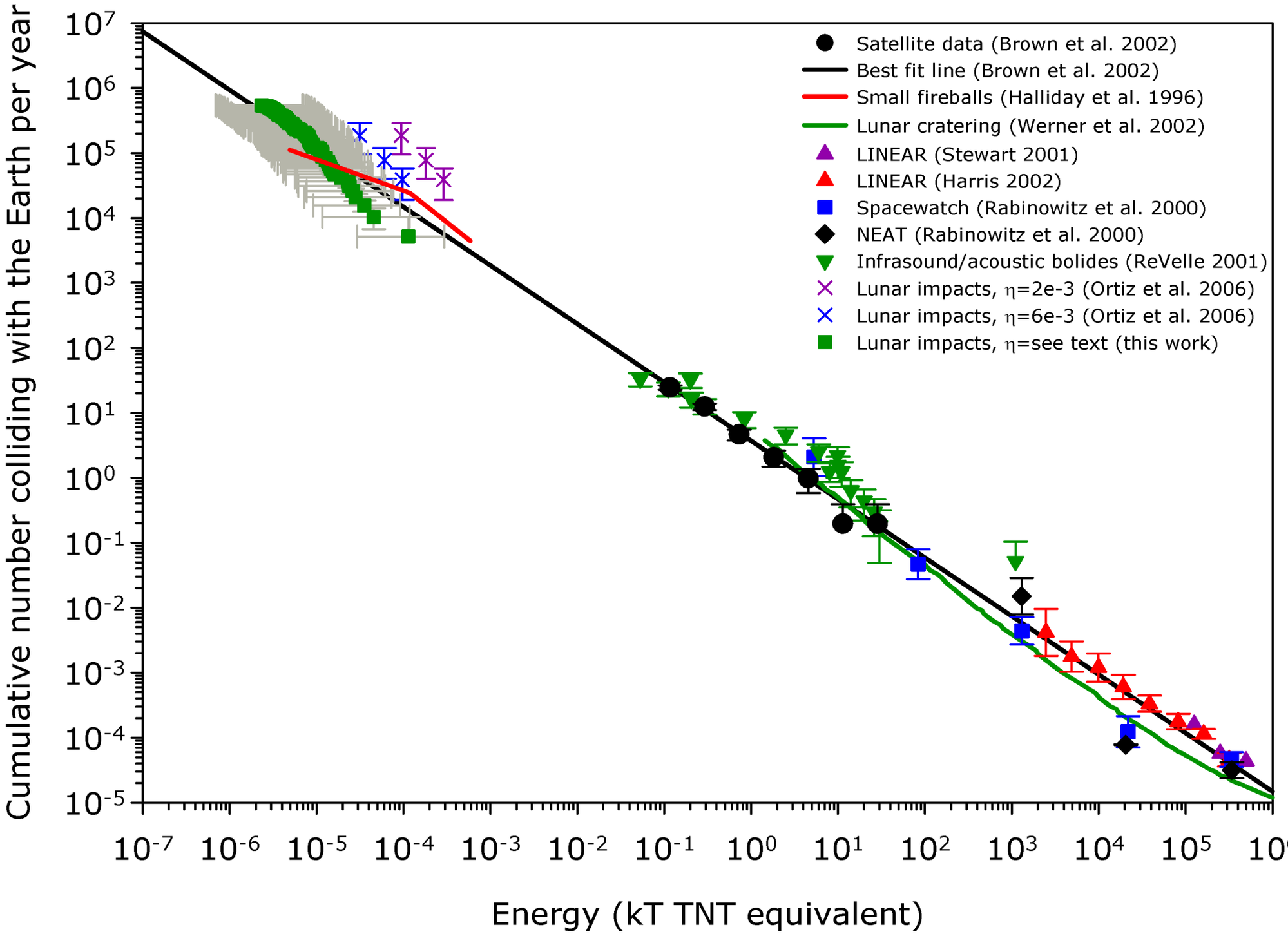


Red error bars - photometric uncertainty; Blue error bars - range of reasonable luminous efficiencies
Squares indicate saturation

The flux to a limiting mass of 30 g is 6.14×10^{-10} m^{-2} yr^{-1}

Summary

- Shower membership determined based on radiant visibility from impact location (zenith distance), time from maximum, and peak zhr
- Meteor showers significant contributor at cm sizes (>60%) - looking into radiant distribution as possible explanation for observed asymmetry
- Uncertainty in luminous efficiency dwarfs photometric errors
- We have used a rigorous photometric procedure (observation of standards, color and extinction corrections, etc) to derive flash magnitudes
  - Brightest flashes are saturated; energy/mass underestimated
- Results consistent with other observational studies


Cumulative number colliding with the Earth per year
10^{7}
10^{6}
10^{5}
10^{4}
10^{3}
10^{2}
10^{1}
10^{0}
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
10^{-7} 10^{-6} 10^{-5} 10^{-4} 10^{-3} 10^{-2} 10^{-1} 10^{0} 10^{1} 10^{2} 10^{3} 10^{4} 10^{5} 10^{6}
Energy (kT TNT equivalent)
Satellite data (Brown et al. 2002)
Best fit line (Brown et al. 2002)
Small fireballs (Halliday et al. 1996)
Lunar cratering (Werner et al. 2002)
LINEAR (Stewart 2001)
LINEAR (Harris 2002)
Spacewatch (Rabinowitz et al. 2000)
NEAT (Rabinowitz et al. 2000)
Infrasound/acoustic bolides (ReVelle 2001)
Lunar impacts, η=2e-3 (Ortiz et al. 2006)
Lunar impacts, η=6e-3 (Ortiz et al. 2006)
Lunar impacts, η=see text (this work)